

# The Optical Gravitational Lensing Experiment. Variable stars in the Sculptor dwarf spheroidal galaxy <sup>1</sup>

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## Abstract

The central area of the Sculptor dwarf galaxy was surveyed for variable stars as a side-program of the OGLE project. Light curves in the V band were obtained for 226 RR Lyr stars and for 3 anomalous cepheids. One previously unknown anomalous cepheid was identified. We discovered also two variables located at the tip of the red giant branch of Sculptor. Out of 226 RR Lyr variables 135 were classified as RRab, 88 as RRc and 2 as RRd. Distribution of periods for RRab stars shows a sharp cut-off at  $P = 0.475$  days. This implies that the bulk of Sculptor RR Lyr stars has metallicity  $[\text{Fe}/\text{H}] \leq -1.7$  on the Zinn-West scale. The average V magnitudes of RRab variables are correlated with their periods. This effect is most probably caused by the spread of metallicities exhibited by variables. Based on the average V magnitudes of RR Lyr stars the apparent distance modulus of Sculptor was determined at  $(m - M)_V = 19.71$ . The color-magnitude diagram of Sculptor reaching  $V \approx 21.4$  and  $I \approx 20.6$  is presented. The observed width of the upper part of the red giant branch indicates range of metallicities  $-2.2 \leq [\text{Fe}/\text{H}] \leq -1.6$  for the Sculptor giants. The observed distribution of stars along the horizontal branch and average value of metallicity imply that age of Sculptor is similar to ages of the relatively young globular clusters from the outer galactic halo. The data about RR Lyr variables in four nearby dwarf galaxies are summarized and discussed briefly.

## 1. Introduction

The Optical Gravitational Lensing Experiment (OGLE) is a long term project with the main goal of searching for dark matter in our Galaxy by identifying microlensing events toward the Galactic Bulge (Udalski et al. 1992, 1994a). At times the Bulge is unobservable we conduct other long-term photometric programs. A complete list of side-projects attempted by the OGLE team can be found in Paczynski et al. (1995). In this paper we present study of variable stars in the Sculptor dwarf galaxy.

The Sculptor galaxy is one of satellites of the Milky Way. It was discovered by Shapley (1938)

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<sup>1</sup> Based on observations collected at the Las Campanas Observatory of the Carnegie Institution of Washington.

as the first dwarf galaxy ever identified. The pioneering search for variable stars in Sculptor was conducted by Baade and Hubble (1939). They discovered about 40 variables, of which all but two brightest were RR Lyr stars. Thackeray (1950) reported 237 variables while van Agt (1978) published list of 602 variables and listed periods for 62 RR Lyr variables and for 3 anomalous cepheids.

## 2. Observations and data reduction

The OGLE project is conducted using the 1-m Swope telescope at Las Campanas Observatory which is operated by Carnegie Institution of Washington. A single  $2048 \times 2048$  pixels Loral CCD chip, giving the scale of 0.435 arcsec/pixel is used as the detector. The initial processing of the raw frames is done automatically in near-real time. Details of the standard OGLE reduction techniques are described by Udalski et al. (1992).

The data for this project were obtained during 1992 and 1993 observing seasons. Detailed logs of observations can be found in Udalski et al. (1992, 1994b). One field centered approximately on the center of the galaxy was observed. Most of the data were obtained during the period from Jun 24 to Sep 5, 1993. The exposure times ranged from 700 to 1100 seconds with 900 seconds being the most frequent value. A total of 87 exposures in the V band and 11 exposures in the I band were collected. The seeing ranged from  $1.2''$  to  $2.2''$  with the average value of about  $1.5''$ .

Extraction of photometry was conducted using procedure similar to that described by Udalski et al. (1992). The DoPHOT photometry program (Schechter et al. 1993) was used to derive profile-fitting photometry. We used the DoPHOT program in the fixed-position mode. The stellar positions were provided from a list of the output photometry taken from the reduction of a "template" image. The frame mr4741 (see Udalski et al. 1994b) was chosen as a template. To cope with the effects caused by the positional changes of the point spread function, each analyzed frame was divided into a  $4 \times 4$  grid of overlapping sub-frames. The point spread function showed only very small variability in these  $540 \times 540$  pixel sub-images. Photometry derived for the "template" sub-frames was transformed to the common instrumental system by application of additive corrections. These corrections were equal to the aperture corrections derived for each sub-frame. The aperture corrections were calculated using the Daophot program (Stetson 1987, 1991). Subsequently instrumental photometry derived for a given sub-frame of a given frame was tied to the common instrumental system of the "template" image. Finally the data base containing photometry from all reduced frames was constructed. The actual procedure of constructing the data base was similar to procedure described by Udalski et al. (1992) and Szymański & Udalski (1993).

The data were calibrated using observations collected during the photometric night of July 13, 1993. Five fields containing 17 standard stars from the Landolt (1992) list were observed on this night. The following relations were obtained:

$$v = \text{const} + V - 0.028 \times (V - I) + 0.086 \times (X - 1.25) \quad (1)$$

$$v - i = \text{const} + 0.952 \times (V - I) + 0.056 \times (X - 1.25) \quad (2)$$

where X is the airmass and a lower case letters correspond to the instrumental magnitudes. This transformation is very similar to the transformation obtained for the 1992 season by Udalski et al. (1992). Two consecutive frames of the Sculptor obtained on the night of July 13, 1993 (frames mr4528 and mr4529 in Udalski et al. 1994b) were used to obtain VI photometry for stars from the monitored field. This photometry was subsequently used to transform instrumental photometry from the data base to the V system. A simplified transformation in the form  $V = v + dv$  was adopted. To determine value of offset  $dv$  an average value of  $(V - v)$  was calculated for stars with

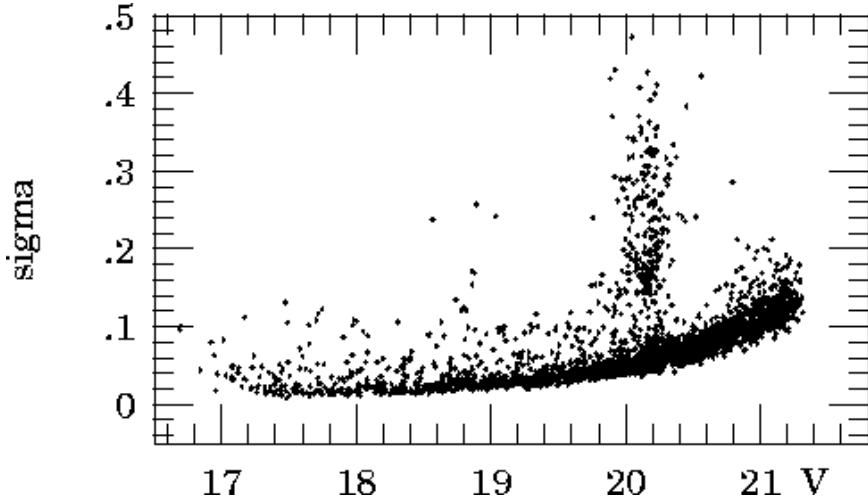


Figure 1: Standard deviation vs. average V magnitude for stars with at least 50 reliable measurements. The group of stars with large values of  $rms$  present at  $V \approx 20.1$  are RR Lyr variables.

19;V;20 and  $0.9 < V - I < 1.0$ . The color term of the V transformation equals 0.028 (see eq. 1). Hence, neglection of this term leads to some systematic errors which do not exceed 0.028 mag for stars with  $0 < V - I < 2.0$ . Colors of Sculptor RR Lyr stars discussed in the next section range from  $V - I \approx 0$  to  $V - I \approx 0.6$ . This range includes variability of color with phase.

### 3. Variable stars

A search for variable stars was made using a  $\chi^2$  test. The total number of stars contained in the data base for the V filter was equal to 6196. Only light curves of 3218 stars which were measured on at least 50 frames were tested. In total, 326 objects satisfying condition  $P(\chi^2) < 1 \times 10^{-4}$  were selected for further examination. The search for variables was limited to the V photometry because of the relatively low number of measurements for the I band. Of 326 candidate variables 95 turned out to be spurious or irregular variables. Almost all certain variables are RR Lyr stars. The 6 exceptions are 3 anomalous cepheids and 3 long period variables. In Fig. 1 we plotted  $rms$  vs. average V magnitude for stars whose light curves were examined for variability.

#### 3.1. RR Lyr variables

The light curve parameters derived for RR Lyr variables are given in Table 1. This table contains also rectangular coordinates of variables. The ID numbers assigned to variables correspond to their running numbers in the data base for the V filter. Periods were determined using Clean (Roberts et al. 1987) and AoV (Schwarzenberg-Czerny 1991) algorithms. In all but very few cases unambiguous value of period could be derived. V1168 and V4780 are double-mode pulsators belonging to RRd variables. For RRd stars we printed the first-overtone periods in Table 1. The fundamental periods of RRd stars V1168 and V4780 were determined at 0.5415 and 0.6441 days, respectively.  $N_V$  is the total number of measurements accepted for a given star (some points with very large formal errors of the photometry were rejected). Columns 4-5 are magnitudes at the maximum and minimum of brightness, respectively. The full amplitude of a light curve is given in column 6. Intensity-mean magnitudes are listed in column 7. They were calculated by numerical integration of the phased light curves. Columns 8-9 are rectangular coordinates corresponding to positions of stars on the template image. The template image (FITS format file) was submitted to the editor of A&A together with the paper (see Appendix A). Assigned types of variable are listed in column 10. A question mark in column 10 indicates uncertain classification of a given star

Figure 2: Phased V-light curves of Sculptor RR Lyr stars. Inserted labels give variables ID and their periods.

while capital letter B indicates variable period or amplitude (i.e. Blazhko effect). The equatorial coordinates of all variables are given in Table 2. A transformation from the rectangular to the equatorial coordinates was derived based on positions of 12 stars from the Guide Star Catalogue (Lasker et al. 1988). The GSC stars were distributed more or less uniformly over the observed field. The adopted plate solution reproduces their equatorial coordinates listed in the GSC with residuals not exceeding 0.7".

An attempt was made to cross-correlate objects from Table 1 with the list of variables given by van Agt (1978). Unfortunately it turned out to be impossible to obtain accurate transformation between van Agt's coordinates and our system of rectangular coordinates. It seems that for many stars from van Agt's list errors of coordinates are much larger than the quoted uncertainty  $\pm 4$  arcsec. No attempt was made to cross-identify variables from both lists by hand. We determined however, that there were 213 van Agt's variables inside the field monitored by us. We identified 5 randomly selected variables from the van Agt's list - namely stars V4, V103, V195, V458 V475 - which were not present on our list of variables. Their light curves were extracted from the data base and it turned out that all five stars do not show any evidence for variability. This indicates that some fraction of stars identified by van Agt (1978) as RR Lyr variables are in fact non-variable objects.

The phased light curves of Sculptor RR Lyr stars are shown in Fig. 2. The tabular data with photometry of all variables were submitted to the editor of A&A (see Appendix A). In Fig. 3 we present a period-V amplitude diagram for the Sculptor RR Lyr stars. Periods and amplitudes of RRab variables are correlated, stars with shorter periods tend to have larger amplitudes. The same relation was observed in some globular clusters harboring rich populations of RR Lyr variables. No correlation between  $P$  and  $A_V$  is observed for the Sculptor RRc variables. The histogram showing distribution of periods for RRab and RRc variables is shown in Fig. 4.

It is known that properties of RR Lyr stars are correlated with metallicity of their parent population. With increasing metallicity the average period  $\langle P_{ab} \rangle$  decreases and the blue edge of the instability strip moves toward bluer colors. Also the relative frequency of RRc stars -  $N_c/(N_c + N_{ab})$  - has tendency to be higher for populations of lower metallicity. Galactic globular clusters are conventionally classified into two groups: Oosterhoff type I (metal-intermediate objects with  $\langle P_{ab} \rangle \approx 0.55$  days) and Oosterhoff type II (metal-poor objects with  $\langle P_{ab} \rangle \approx 0.65$ ). Recent extensive reviews of this subject and summary of observational data can be found in Sandage (1993a) and in Bono et al. (1994). For the Sculptor variables we obtained  $\langle P_{ab} \rangle = 0.585$  ( $\langle \log P_{ab} \rangle = -0.236$ ) and  $N_c/(N_c + N_{ab}) = 88/222 = 0.40$  what corresponds formally to "Oosterhoff-intermediate" type of population. In fact no galactic globular cluster is known with  $\langle \log P_{ab} \rangle$  in the range of -0.21 to -0.24, although such "Oosterhoff-intermediate" clusters are known in the Large Magellanic Cloud (e.g. Bono et al. 1994). It is known that giants in the Sculptor galaxy show a range of metallicities (Kunkel and Demers 1977, Da Costa 1984). Distribution of periods of the Sculptor RRab variables shows a sharp cut-off at  $P_{ab} = 0.475$  days ( $\log P_{ab} = -0.32$ ). Sandage (1993a) obtained the following relation between the period and the metallicity at the blue fundamental edge of the instability strip:

$$\log P_{ab} = -0.122 \times [\text{Fe}/\text{H}] - 0.500 \quad (3)$$

where  $[\text{Fe}/\text{H}]$  is on the Butler-Blanco (Butler 1975, Blanco 1992) scale. For  $P_{ab} = 0.475$  days Eq. 3 implies  $[\text{Fe}/\text{H}] = -1.5$ . Hence, we may infer that the bulk of the Sculptor RR Lyr stars have

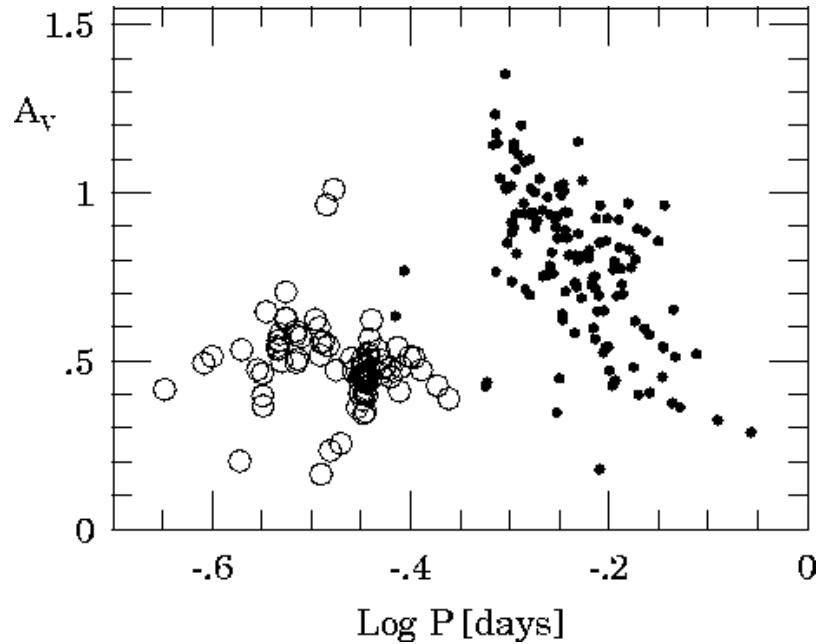


Figure 3: Period – V amplitude diagram for RR Lyr stars in the Sculptor dwarf galaxy. Filled circles – RRab variables, open circles – RRc variables.

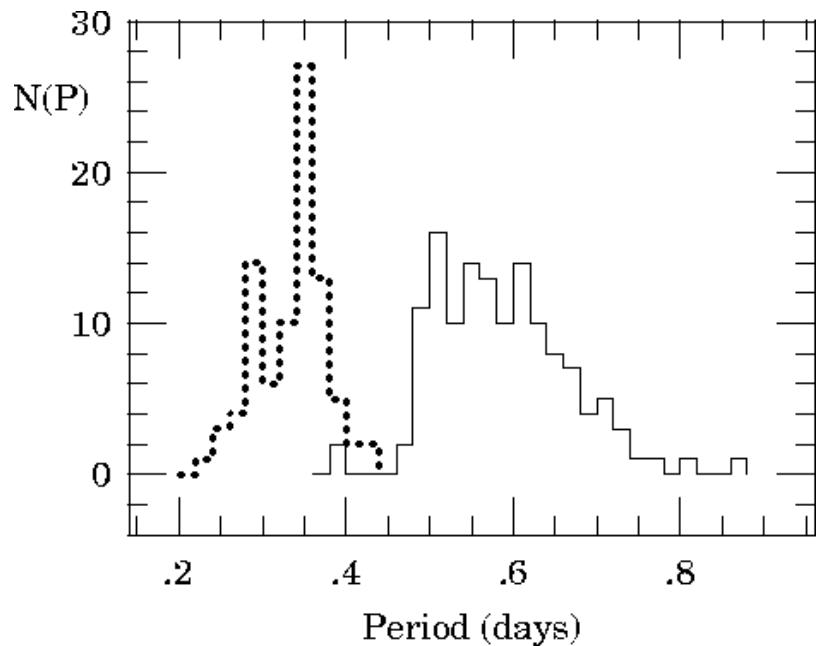


Figure 4: Period distribution of the RR Lyr stars in the Sculptor dwarf galaxy. Distribution for RRab stars is marked with the solid line while distribution for RRc stars is marked with the dashed line. Bins are 0.025 days wide.

metallicities equal or lower than  $-1.5$ . The Butler-Blanco scale is 0.2 dex more metal rich than the cluster scale of Zinn and West (1984). Hence, distribution of the Sculptor RRab stars shows cut-off at the period corresponding to  $[\text{Fe}/\text{H}] \approx -1.7$  on Zinn-West metallicity scale. Our sample of RRab stars includes two variables with very short periods, V3761 with  $P = 0.384$  days and V5330 with  $P = 0.392$  days. Based on Eq. 3 we arrive to conclusion that metallicity of these stars is  $[\text{Fe}/\text{H}] \leq -0.7$  on the scale of Zinn and West. The light curve of V5330 exhibits Blazhko effect.

In Fig. 5 we show a period vs. average V magnitude diagram. Three variables with periods close to 0.5 day whose light curves had poorly defined maxima (V2058, V2558 and V4785) were not taken into account. Average V magnitudes listed for these three stars in Table 1 are undoubtedly overestimated. Average V magnitudes of RRab stars show clear correlation with periods. In particular, the lower envelope of the  $\langle V \rangle$  distribution moves toward brighter magnitudes for longer periods. In their recent study Nemec et al. (1994) found a slope  $\Delta M_V / \Delta \log P = -0.52 \pm 0.11$  for the  $P - L - [\text{Fe}/\text{H}]$  relation in V. Using the data shown in Fig. 5 we obtained  $\Delta M_V / \Delta \log P \approx -1.7$ . Most likely the correlation between  $\langle V \rangle$  and  $P$  observed for the Sculptor RRab variables is in large part due to metallicity spread exhibited by stars in this dwarf galaxy (Kunkel and Demers 1977, Da Costa 1984). Absolute magnitudes of RRab variables are strongly correlated with metallicity,  $M_V$  decreases with decreasing metallicity. On the other hand, average periods of RRab stars are longer for lower metallicities. Hence, for a mixture of RRab variables with different metallicities we may expect presence of stronger correlation between  $\langle M_V \rangle$  and a period than it is observed for samples of variables with constant metallicity.

The average values of  $\langle V \rangle$  are  $20.14 \pm 0.09$  and  $20.12 \pm 0.11$  for RRab and RRc variables respectively. Adopting  $[\text{Fe}/\text{H}] = -1.7$  ( $[\text{Fe}/\text{H}] = -1.9$  on the Zinn-West scale) for the average metallicity of Sculptor RRab stars (see Section 4) and using relation  $\langle M_V \rangle = 0.30 \times [\text{Fe}/\text{H}] + 0.94$  derived by Sandage (1993b) we obtain  $(m - M)_V = 19.71$  for the apparent distance modulus of the galaxy. This value is slightly larger than  $(m - M)_V = 19.56$  obtained by Kunkel and Demers (1977).

### 3.2. Anomalous cepheids and other bright variables

Anomalous cepheids are pulsating variables which are 1-2 mag brighter than RR Lyr stars. Their periods range from about 9 hours to about 38 hours. Anomalous cepheids were discovered in several dwarf spheroidal systems and in the Small Magellanic Cloud. Only one is known in galactic globular clusters. Nemec et al. (1994) published recently an extensive summary of data for known anomalous cepheids. Masses of anomalous cepheids are estimated at 1-2 solar masses. It is believed that these stars are created by mass transfer in binary systems. Three anomalous cepheids were discovered in the Sculptor galaxy so far (see van Agt 1978). Two of these stars were originally labeled A and B by Baade and Hubble (1939). The third one was discovered by Thackeray (1950). Smith and Stryker (1986) obtained low-resolution spectra of the Sculptor anomalous cepheids and determined their metallicities. They obtained  $[\text{Fe}/\text{H}] = -1.9 \pm 0.2$ ,  $-1.8 \pm 0.2$  and  $-2.2 \pm 0.3$  for V25, V26 and V119, respectively (here variables are identified by van Agt's numbers).

The field monitored by us contained two previously known anomalous cepheids, namely variables numbered V26 and V119 by van Agt (1978). One new variable of this type (V5689) was discovered in our data. This new variable forms a close visual binary with a brighter star located at a distance of just 2.1 arcsec. This precluded probably its discovery during previous surveys of the Sculptor galaxy. The light curve parameters derived for anomalous cepheids observed by us are given in Table 3. This table contains the same quantities as Table 1. Periods derived for V734 and V3302 agree with periods listed by van Agt (1978) and by Swope (1968). The light curves of three observed anomalous cepheids are shown in Fig. 6. Photometry of variable V5689

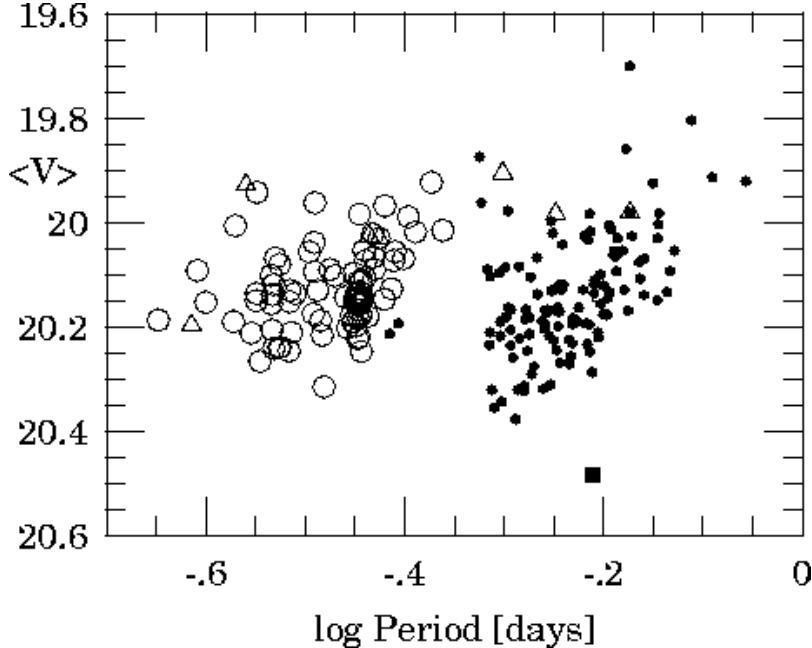


Figure 5: Average V magnitude vs. period for Sculptor RR Lyr stars. RRab stars are marked with filled circles while RRc stars are marked with open circles. Variables with Blashko effect are marked with open triangles. Position of deviating variable V4686 is shown with a filled square.

is relatively noisy due to presence of bright visual companion to this star. Table 3 contains also data for two low-amplitude variables V274 and V687. These stars showed changes of brightness not exceeding 0.20 mag and with characteristic time scale of about 30 days. Our data are too sparse to decide if the observed variability is periodic. Both variables are located at the tip of the red giant branch of the galaxy (see next section). Their light curves for 1993 season are shown in Fig. 7.

The equatorial coordinates of variables discussed in this section can be found at the end of Table 2.

#### 4. The color-magnitude diagram

The first color-magnitude diagram (hereafter CMD) of Sculptor reaching the horizontal branch was published by Kunkel and Demers (1977). They obtained photographic photometry for the field covering central part of the galaxy. Their CMD showed a predominantly red horizontal and wide red giant branch indicating presence of a significant abundance spread among Sculptor stars. Norris and Bessell (1978) suggested, based on the data of Kunkel and Demers (1977), that the abundance range present among Sculptor giants was equal to the abundance difference between the globular clusters M92 and M3, i.e. approximately 0.6 dex. Subsequently Da Costa (1984) obtained deep CMD reaching to the main-sequence turnoff for the relatively small field located just out of the core radius of Sculptor. His data confirmed finite width of the red giant branch of the galaxy. Based on comparison with theoretical isochrones Da Costa (1984) suggested that the bulk of the Sculptor stars may be 2-3 Gyr younger than stars in galactic globular clusters.

In Fig. 8 we show V vs. V-I and I vs. V-I CMDs of Sculptor. Stars which are known RR Lyr variables were not plotted in these figures. We marked however, positions of three anomalous cepheids and two bright variables discussed in Section 3.2. In contrast to the photometry of Kunkel and Demers (1977) our CMD of Sculptor does show a relatively well populated blue horizontal branch (HB). The limiting magnitude of the I photometry coincides with the observed

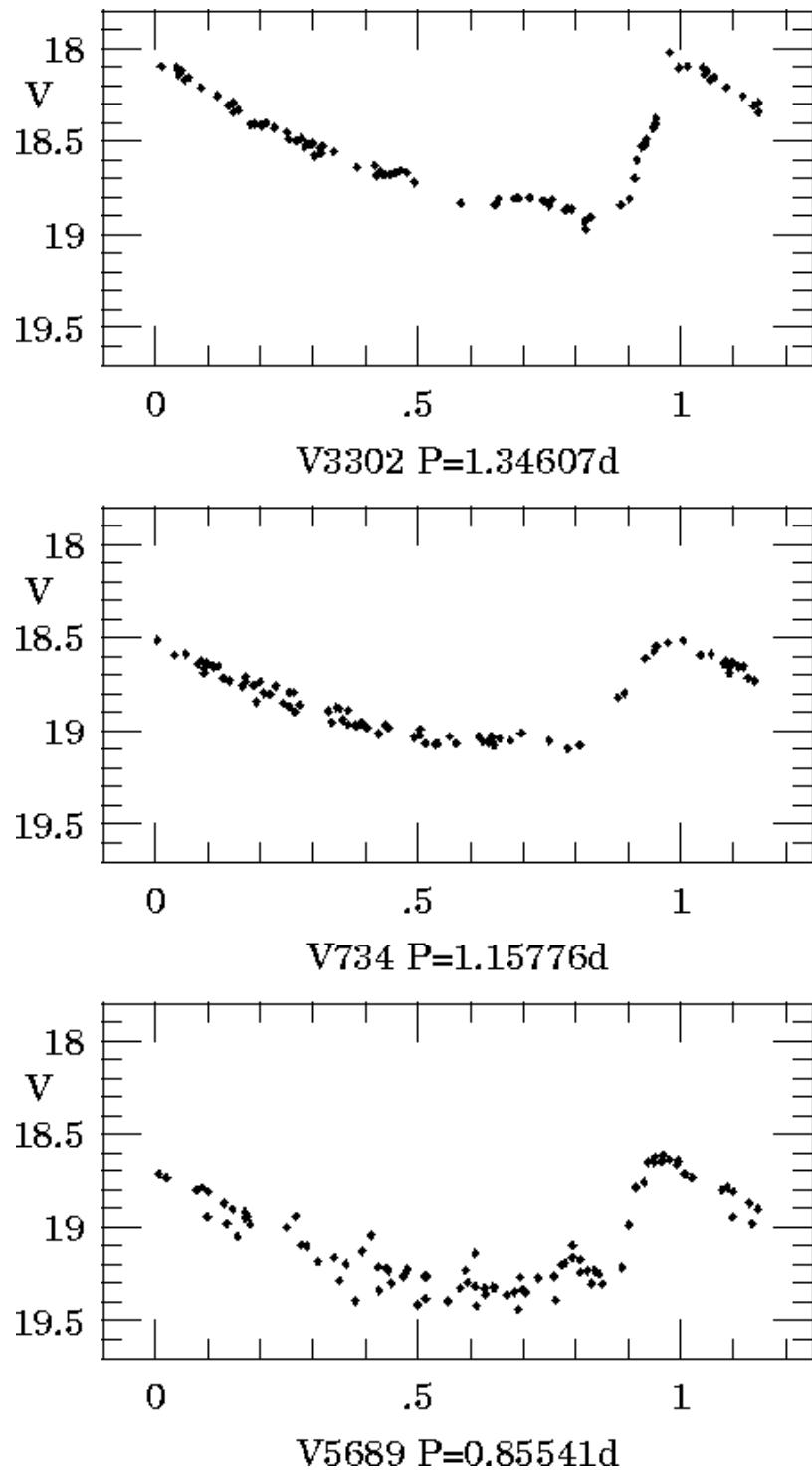


Figure 6: Phased light curves of Sculptor anomalous cepheids. Note change of the average magnitude with a period.

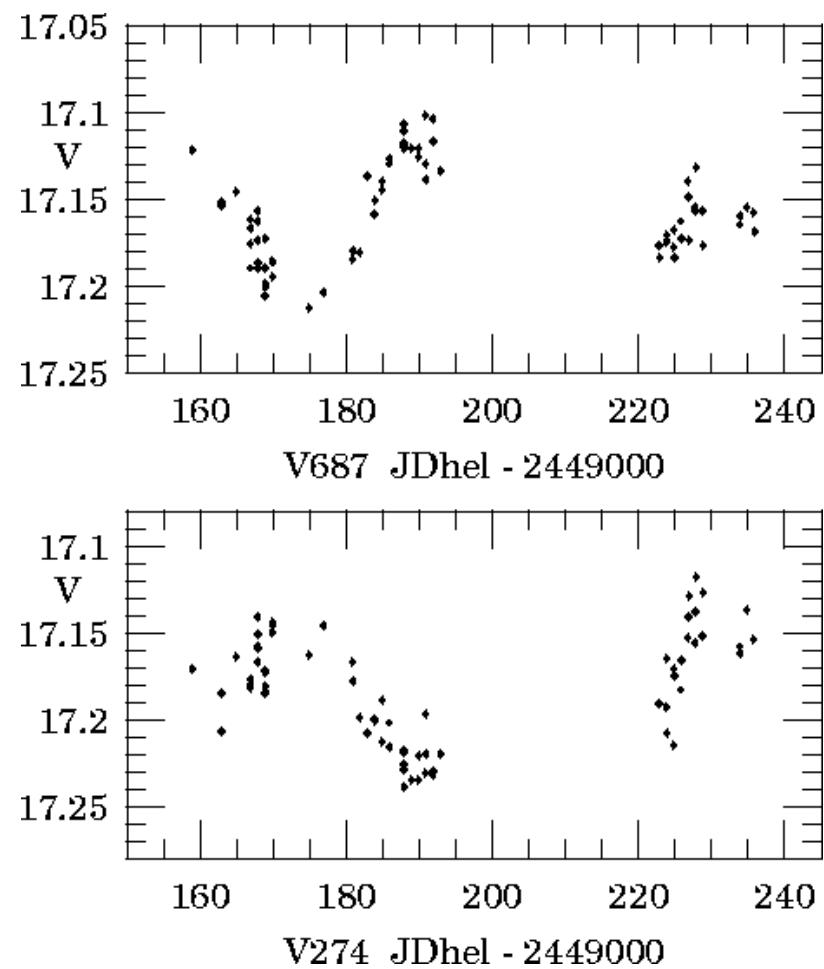


Figure 7: Light curves of two variable stars from the tip of the giant branch of Sculptor

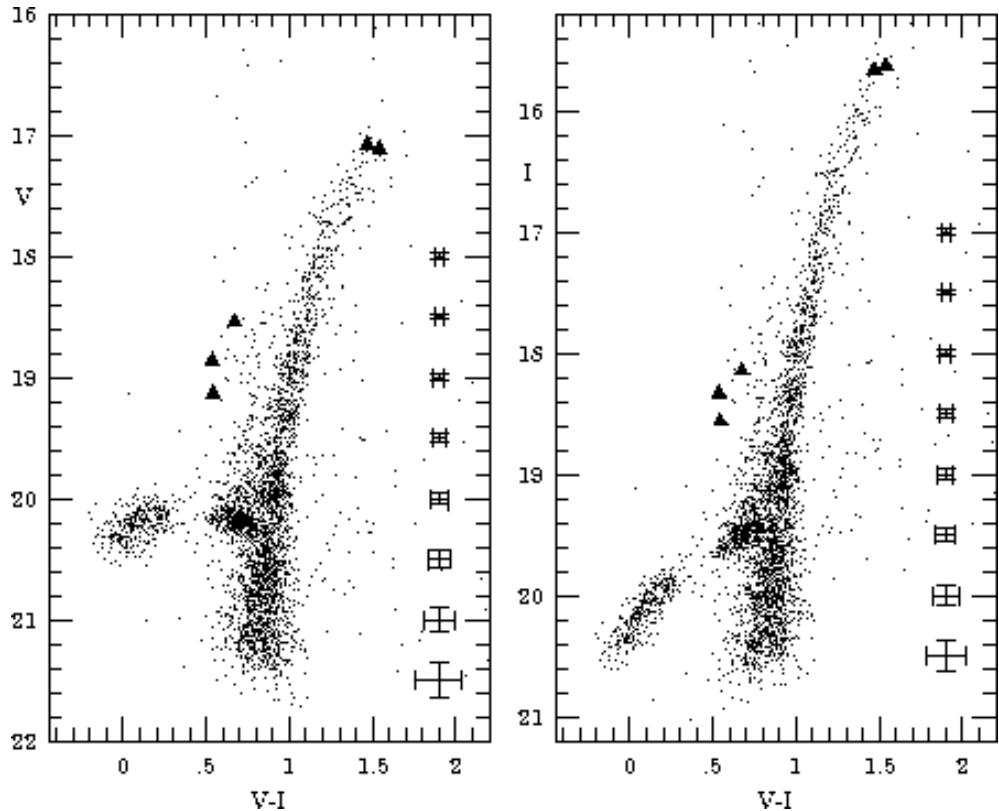


Figure 8: The  $V/V-I$  and  $I/V-I$  Color-magnitude diagrammes for the central part of the Sculptor dwarf galaxy. Stars known to be RR Lyr variables were not plotted. Positions of three anomalous cepheids and two bright variables of unknown type are marked with triangles. The adopted  $V$  magnitudes of variables correspond to their average  $V$  magnitudes (Table 3). The  $V-I$  colors and  $I$  magnitudes of variables were measured at some random phases of their light curves. The error bars shown indicate the size ( $\pm 1\sigma$ ) of the formal errors for stars from the red giant branch.

faint-blue end of the HB. Therefore, we cannot rule out the possibility that the blue part of the HB of Sculptor extends in fact toward fainter magnitudes than it is implied by data shown in Fig. 8. Morphology of the HB can be described with the index  $(B - R)/(B + V + R)$  which was introduced by Lee (1989).  $B$ ,  $V$  and  $R$  are the numbers of blue, variable and red HB stars, respectively. Using data presented in Fig. 8 we obtained  $B = 288$ ,  $V = 226$  and  $R = 431$ . The following limits on the location of the red HB stars were assumed:  $19.95 < V < 20.26$  and  $0.50 < V - I < 0.81$ . The red part of the HB merges in fact with the RGB and therefore it is likely that we overestimated slightly the value of  $R$ . At the same time the value of  $B$  is probably underestimated. Hence, our determination of  $(B - R)/(B + V + R) = -0.22$  for Sculptor should be regarded as a lower limit on its HB index. However, even if we missed as many as 50% stars from the blue HB (what we consider very unlikely based on the unpublished photometry of Sculptor obtained recently by Kaluzny and Krzemiński) the HB index would rise only to  $(B - R)/(B + V + R) = +0.1$ . Location of Sculptor on the  $[\text{Fe}/\text{H}]$  vs. HB-type diagram indicates that its age is similar to ages of the relatively young globular clusters from the outer galactic halo (see Fig. 7 in Lee et al. 1994). This conclusion is in agreement with Da Costa (1984) who found, based on photometry of turn-off stars, that the bulk of Sculptor stars are younger than stars in M92.

In Fig. 9 we show CMD of Sculptor with over-imposed fiducials for giant branches of globular clusters M2 and M15 (Da Costa and Armandroff 1990). The fiducials were shifted assuming  $E(V - I) = 0.03$  and  $(m - M)_V = 19.71$ . The galactic coordinates of Sculptor are  $(l, b) = (283, -83)$  and therefore we adopted for it a reddening appropriate for the areas near the South galactic pole. On the Zinn-West scale metallicities of M2 and M15 are  $[\text{Fe}/\text{H}] = -1.58$  and  $[\text{Fe}/\text{H}] = -2.17$ , respectively. The upper part of the red giant branch of Sculptor is bracketed by relations for M2 and M15. This indicates, that most of Sculptor stars have metallicities  $-2.2 < [\text{Fe}/\text{H}] < -1.6$ . This result is consistent with earlier estimates (Da Costa 1984, Norris and Bessell 1978) and with average value of metallicity obtained for RRab stars in Section 3 of this paper. The boundaries of the lower part of the RGB of Sculptor are shifted slightly to the blue relatively to relations defined by M2 and M15. This effect can be explained by a slightly lower age of bulk of Sculptor stars in comparison with ages of M2 and M15. Concluding this section we note, that significant fraction of stars which are located to the blue of the RGB in Fig. 9 and have  $18.3 < V < 20.0$  are probably stars from the asymptotic giant branch of Sculptor.

## 5. Summary

The global properties of the Sculptor galaxy inferred from our data are in agreement with results of the earlier studies. Distribution of periods for RRab stars gives  $[\text{Fe}/\text{H}] \leq -1.7$  for the bulk of stars from the horizontal branch. The range of colors exhibited by stars from the upper part of the red giant branch implicates spread in  $[\text{Fe}/\text{H}]$  from about -2.2 to about -1.6. Very similar results were obtained based on the analysis of the CMD of Sculptor by Da Costa (1984) and by Norris and Bessell (1978). Also metallicities obtained for 3 Sculptor anomalous cepheids by Smith and Stryker (1986) are within the quoted range of  $[\text{Fe}/\text{H}]$ . Morphology of the horizontal branch of Sculptor connected with the relatively low average metallicity of its stars indicates that age of the galaxy is close to the ages of youngest galactic globulars. This agrees with conclusion of Da Costa (1984) who found that turnoff of Sculptor is redder than turnoff of M92 although both objects have similar metallicities.

Besides Sculptor some detailed data about population of RR Lyr variables are available for three other dwarf galaxies from the Local Group: Ursa Minor (Nemec et al. 1988), Draco (Nemec 1985) and Carina (Saha et al. 1986). These data are summarized in Table 4 where we listed also metallicities adopted for each galaxy. According to Stetson (1984) stars in Ursa Minor show small range of metallicity and age. Carina contains two populations of stars with ages  $\tau > 10$  and

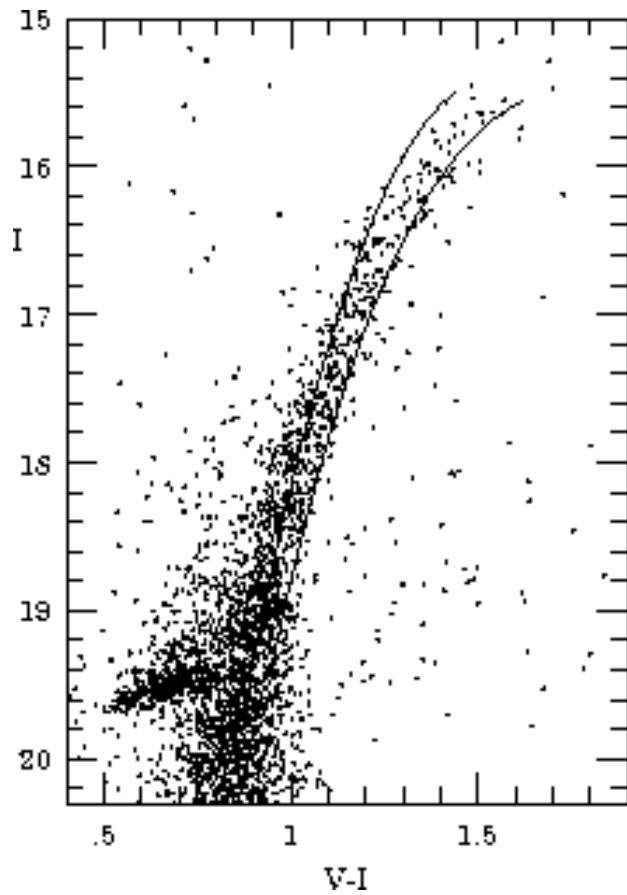


Figure 9: The I/V-I color-magnitude diagram of Sculptor. Stars known to be variables were not plotted. The solid lines show location of red giant branches for M2 and M15.

$\tau \approx 6$  Gyr. Metallicity of the older population is estimated at  $[\text{Fe}/\text{H}] = -2.2$  (Smecker-Hane et al. 1994). Only older population of Carina may form RR Lyr variables. The Draco stars seem to form two groups in respect of metallicity, one with an average  $[\text{Ca, Mg}/\text{H}]$  near  $-1.6 \pm 0.2$ , and the other  $-2.3 \pm 0.2$  (Lehnert et al. 1992). Six out of fourteen giants observed by Lehnert et al. (1992) belonged to the low-abundance group. Therefore, we may expect that significant fraction of stars from the HB of Draco have  $[\text{Fe}/\text{H}] \approx -2.2$ . The CMD of Draco published by Carney & Seitzer (1986) does not show any extended blue horizontal branch typical for very old globulars. Most probably Draco RR Lyr variables belong to the group of low-abundance stars. Figure 10 shows distribution of periods for RRab and RRc stars in Carina, Draco and Ursa Minor galaxies (distribution for Sculptor is shown in Fig. 4). We plotted in Fig. 10 also distributions of periods for variables from globular clusters M68 (Walker 1994) and Ru 106 (Kaluzny et al. 1995). M68 belongs to the group of the oldest clusters while Ru 106 is one of the youngest galactic globular clusters known (eg. Lee et al. 1994). Metallicities of M68 and Ru 106 are estimated at  $-2.1$  and  $-1.9$ , respectively. Those values are similar to average metallicities of RR Lyr populations in four discussed dwarf galaxies. Data presented in Figs. 4 and 10 and in Table 4 indicate that ages of RR Lyr populations in Sculptor and Ursa Minor are comparable. Ursa Minor has larger value of  $\langle P_{ab} \rangle$  and longer value of  $P_{ab}$  at the blue edge of the instability strip in comparison with Sculptor. This suggests that RR Lyr variables in Ursa Minor have lower average metallicity than Sculptor variables. In all four galaxies distributions of periods of RRc variables show maxima near  $P = 0.40$  days. It is interesting that Sculptor and Ursa Minor show secondary peaks at  $P \approx 0.32$  days. Such bimodal distributions are not common among globular clusters. Data presented in Table 4 indicate that populations of RR Lyr stars in Sculptor and Ursa Minor are older than Ru 106 but younger than M68. RR Lyr stars in Carina and Draco seem to be coeval or only marginally older than Ru 106.

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### Appendix A

Tables containing light curves of all variables discussed in this paper are published by A&A at the Centre de Données de Strasbourg, where they are available in electronic form: See the editorial in A&A 1993, Vol. 280, page E1. We also submitted to the data base an image allowing identification of all variables.

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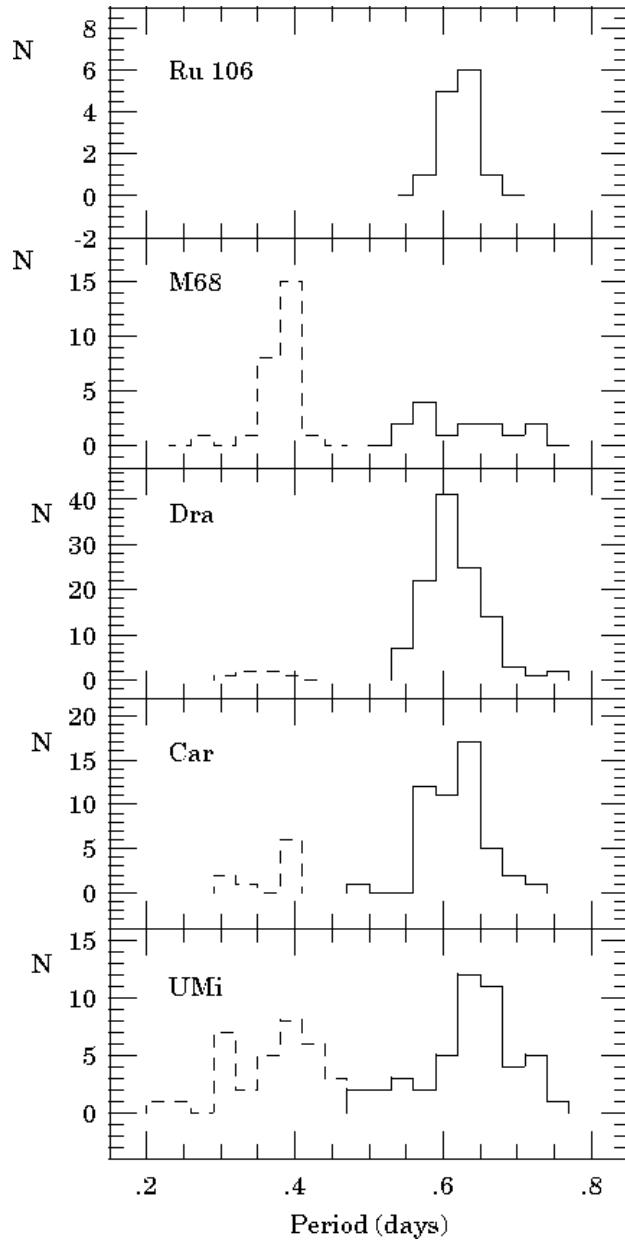


Figure 10: Period distribution of the RR Lyr stars in Carina, Draco and Ursa Minor spheroidal galaxies. Distributions for globular clusters M68 and Ru 106 are also shown. Bins are 0.03 days wide. Solid line corresponds to RRab variables while dashed line corresponds to RRc variables. Variables of type RRd were omitted.

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Table 1: Light curve parameters and rectangular coordinates of Sculptor RR Lyr variables. Coordinates X and Y are expressed in pixels (1 pixel equals 0.435"). See text for more details.

ID	P(days)	Nv	Vmax	Vmin	Av	$\langle V \rangle$	X	Y	type
33	0.30906	80	19.86	20.43	0.57	20.137	141.0	27.2	c
37	0.50871	82	19.65	20.58	0.94	20.237	205.2	83.6	ab
38	0.37123	82	19.90	20.36	0.46	20.091	425.2	108.2	c
54	0.61450	82	19.89	20.54	0.65	20.288	272.1	321.2	ab
59	0.35969	82	19.95	20.39	0.44	20.157	435.4	357.4	c
71	0.43494	82	19.85	20.24	0.39	20.016	125.3	405.9	c
116	0.73599	82	19.79	20.30	0.51	20.094	493.9	281.2	ab
321	0.60184	82	19.70	20.50	0.80	20.130	98.0	610.6	ab
356	0.56950	83	19.57	20.51	0.94	20.120	73.0	810.7	ab
357	0.55808	83	19.72	20.61	0.90	20.312	223.4	814.2	ab
361	0.29759	83	19.92	20.55	0.63	20.241	111.4	850.4	c
366	0.68510	83	19.72	20.31	0.60	20.077	296.2	874.6	ab
368	0.35896	83	19.91	20.37	0.46	20.154	233.3	875.8	c
377	0.29522	83	19.84	20.33	0.50	20.069	491.4	927.0	c
385	0.62854	83	19.50	20.42	0.92	20.141	86.8	968.0	abB
403	0.33033	71	20.18	20.41	0.23	20.316	28.6	568.7	c
406	0.55025	83	19.77	20.56	0.78	20.195	499.1	580.1	ab
411	0.22499	83	19.95	20.37	0.41	20.188	245.5	594.2	c
416	0.52602	83	19.56	20.58	1.01	20.187	206.6	603.2	ab
439	0.49612	78	19.34	20.69	1.35	20.097	290.9	764.6	ab
462	0.52494	83	19.52	20.62	1.10	20.324	79.9	848.1	ab
463	0.56842	83	19.55	20.55	1.00	20.200	180.7	847.8	ab
493	0.68687	83	19.58	20.46	0.88	20.109	71.3	974.9	ab
737	0.33863	82	19.94	20.20	0.25	20.103	102.4	1005.5	c
753	0.49002	83	19.51	20.56	1.04	20.356	308.2	1084.6	ab
763	0.29312	83	19.89	20.43	0.53	20.139	265.9	1146.5	c
771	0.81187	83	19.74	20.06	0.32	19.914	75.3	1177.7	ab
782	0.48550	83	19.45	20.63	1.18	20.104	111.0	1222.5	ab
786	0.27909	83	19.96	20.43	0.47	20.213	277.7	1252.3	c
793	0.35993	83	19.92	20.37	0.44	20.136	266.7	1304.1	c
803	0.57363	83	19.49	20.43	0.94	20.043	369.0	1370.2	ab
811	0.36314	83	19.92	20.37	0.45	20.107	442.3	1413.9	c
853	0.51955	71	19.75	20.47	0.71	20.223	59.3	1116.8	ab
860	0.56222	83	20.00	20.45	0.45	20.227	109.5	1160.1	ab
1132	0.63158	79	19.88	20.35	0.47	20.122	352.0	1534.8	ab
1139	0.51892	79	19.37	20.47	1.09	20.086	449.8	1616.1	ab
1142	0.67062	79	19.39	20.00	0.62	19.701	364.0	1637.9	ab
1149	0.32342	79	19.86	20.03	0.16	19.963	303.4	1690.8	c
1164	0.60621	79	19.80	20.53	0.73	20.194	177.3	1819.3	ab
1168	0.40358	79	19.74	20.21	0.48	19.982	274.7	1891.5	d
1178	0.42362	73	19.74	20.16	0.43	19.924	77.2	2021.5	c
1204	0.29233	79	19.83	20.37	0.54	20.102	108.8	1616.3	c
1256	0.58717	79	19.69	20.49	0.80	20.233	115.4	1966.0	ab
1261	0.63037	78	19.86	20.40	0.54	20.177	450.0	2001.0	ab
1411	0.66458	80	19.46	20.24	0.78	19.860	630.6	74.8	ab
1424	0.61230	79	19.44	20.36	0.92	20.018	963.6	159.5	ab
1439	0.35606	75	19.93	20.39	0.46	20.145	1000.0	270.3	c
1446	0.77331	80	19.53	20.05	0.52	19.805	908.3	311.7	ab
1457	0.71782	80	19.40	20.36	0.96	19.983	717.5	375.3	ab
1462	0.56113	80	19.40	20.41	1.02	20.021	846.3	410.4	ab
1470	0.50565	80	19.69	20.59	0.90	19.979	846.8	451.5	ab
1482	0.29810	79	19.71	20.42	0.70	20.081	954.0	466.4	c
1491	0.35786	80	19.96	20.36	0.40	20.154	541.6	77.3	c
1519	0.35685	80	19.95	20.43	0.48	20.178	719.8	239.2	c
1546	0.53124	80	19.52	20.52	1.00	20.215	678.1	363.6	ab
1553	0.71644	80	19.69	20.23	0.54	20.004	986.1	408.0	ab
1555	0.52724	80	19.59	20.53	0.93	20.168	625.2	411.2	ab
1558	0.24301	80	19.92	20.41	0.49	20.198	513.4	424.3	cB
1566	0.57028	80	19.56	20.45	0.89	20.172	637.6	448.2	ab
1823	0.29846	83	19.94	20.56	0.63	20.240	541.6	774.6	c
1824	0.47550	83	19.70	20.14	0.44	19.963	595.6	782.9	ab
1830	0.51784	83	19.64	20.61	0.97	20.322	852.2	792.3	ab
1838	0.70752	83	19.51	20.36	0.86	19.926	742.5	841.1	ab
1873	0.29230	83	19.88	20.42	0.54	20.157	621.2	956.7	c
1874	0.26901	83	19.76	20.30	0.53	20.007	686.7	956.5	c
1875	0.33319	83	19.48	20.56	1.01	20.039	923.3	956.6	cB

Table 1: - continued

ID	P(days)	Nv	Vmax	Vmin	Av	< V >	X	Y	type
1877	0.56716	82	19.79	20.41	0.62	20.171	588.9	964.2	ab
1890	0.36376	83	19.86	20.48	0.62	20.074	744.8	541.8	c
1899	0.64671	83	19.49	20.33	0.84	20.056	567.8	519.6	ab
1910	0.57285	83	19.59	20.46	0.87	20.130	854.5	539.7	ab
1914	0.57051	80	19.80	20.50	0.71	20.270	805.0	548.2	ab
1926	0.55025	83	19.79	20.55	0.77	20.204	499.1	580.1	ab
1930	0.61118	83	19.91	20.47	0.56	20.249	886.7	605.0	ab
1932	0.50604	83	19.42	20.56	1.15	20.164	553.3	607.1	ab
1940	0.69306	83	19.81	20.39	0.58	20.140	588.5	633.6	ab
1941	0.36567	83	19.92	20.40	0.47	20.181	719.4	633.2	c
1943	0.55116	83	19.61	20.54	0.93	20.169	976.4	643.5	ab
1997	0.62674	83	19.64	20.49	0.86	20.101	904.4	823.9	ab
2004	0.58735	83	19.38	20.54	1.15	20.196	882.0	842.2	ab
2012	0.71475	83	19.89	20.35	0.45	20.150	905.2	855.9	ab
2021	0.62292	83	19.86	20.39	0.52	20.212	784.0	876.0	ab
2048	0.35836	83	19.84	20.44	0.61	20.150	797.4	979.6	cB
2058	0.50350	83	19.72	20.60	0.88	20.404	973.2	999.8	ab
2059	0.49692	83	19.49	20.51	1.02	20.191	729.6	1001.1	ab
2410	0.53183	84	19.67	20.57	0.89	20.183	788.3	1014.8	ab
2421	0.40831	84	19.80	20.27	0.47	20.019	678.1	1060.6	c
2422	0.48446	84	19.49	20.72	1.23	20.236	957.5	1061.0	ab
2423	0.55906	84	19.85	20.20	0.35	19.998	998.7	1063.6	ab
2424	0.34878	84	19.93	20.40	0.47	20.203	546.7	1067.1	c
2425	0.87792	84	19.81	20.10	0.29	19.922	647.2	1072.4	ab
2450	0.61802	84	19.54	20.50	0.96	20.112	671.9	1148.4	ab
2455	0.63622	82	19.92	20.35	0.43	20.178	512.6	1181.8	ab
2458	0.35769	84	19.94	20.39	0.45	20.185	828.3	1191.6	c
2467	0.35809	84	19.93	20.34	0.41	20.133	969.7	1222.5	c
2470	0.69339	84	19.85	20.26	0.41	20.070	743.2	1230.3	ab
2471	0.65023	84	19.71	20.44	0.73	20.094	820.6	1233.7	ab
2482	0.26786	84	20.11	20.31	0.20	20.191	543.8	1251.6	c
2502	0.32769	82	19.69	20.65	0.96	20.189	523.7	1335.5	c
2528	0.60323	84	19.50	20.33	0.83	20.027	869.6	1392.1	ab
2545	0.67408	84	19.50	20.39	0.89	20.027	821.1	1478.2	ab
2552	0.53444	84	19.64	20.55	0.92	20.292	656.1	1096.3	ab
2555	0.50272	84	19.50	20.52	1.02	20.087	660.8	1261.9	ab
2558	0.50340	84	19.71	20.62	0.91	20.419	973.2	999.8	ab
2559	0.49692	84	19.51	20.52	1.01	20.219	729.5	1001.0	ab
2562	0.38627	83	19.88	20.42	0.54	20.128	907.8	1006.0	c
2566	0.58356	84	19.77	20.58	0.81	20.267	592.7	1011.0	ab
2575	0.61108	84	19.52	20.27	0.75	19.984	578.0	1035.2	ab
2606	0.58531	84	19.81	20.53	0.72	20.257	719.1	1132.1	ab
2627	0.57508	84	19.64	20.46	0.81	20.121	529.4	1209.0	ab
2639	0.28961	84	19.93	20.47	0.54	20.212	739.1	1254.4	c?
2689	0.51136	84	19.46	20.57	1.11	20.260	740.2	1480.7	ab
2699	0.48517	84	19.73	20.50	0.76	20.212	668.1	1497.1	ab
2991	0.55264	81	19.63	20.45	0.82	20.175	747.1	1526.2	ab
3004	0.71550	81	19.75	20.30	0.54	20.031	653.2	1599.7	ab
3009	0.36013	81	19.72	20.25	0.52	19.971	890.2	1625.4	ab?
3016	0.36031	81	19.90	20.35	0.46	20.111	811.8	1638.8	c
3019	0.73295	81	19.63	20.28	0.65	19.960	711.6	1650.5	abB
3024	0.36657	80	19.76	20.52	0.76	20.027	533.7	1699.2	?B
3026	0.64546	81	19.50	20.42	0.92	20.063	881.8	1707.5	ab
3039	0.65198	81	19.59	20.29	0.70	20.031	973.3	1843.1	ab
3043	0.62390	81	19.83	20.48	0.65	20.221	983.6	1857.9	ab
3044	0.35393	81	19.90	20.31	0.40	20.098	617.3	1874.6	c
3104	0.35700	81	20.10	20.44	0.34	20.223	887.8	1763.8	c
3113	0.59324	81	19.51	20.55	1.03	20.191	724.3	1817.4	ab
3125	0.53310	81	19.53	20.45	0.92	20.106	991.1	1905.1	ab
3126	0.35294	81	19.97	20.42	0.44	20.191	946.6	1909.5	c
3143	0.35421	74	19.95	20.39	0.44	20.150	942.9	2014.4	c
3318	0.64023	75	19.90	20.34	0.44	20.134	1296.8	32.0	ab
3319	0.56498	75	19.48	20.47	0.99	19.984	1448.3	32.0	abB
3320	0.28247	75	19.94	20.33	0.40	20.137	1333.7	66.9	c
3345	0.35606	73	19.94	20.39	0.45	20.156	1000.0	270.3	c
3346	0.35753	75	19.92	20.37	0.45	20.115	1245.4	280.0	c
3365	0.66807	75	19.86	20.34	0.48	20.170	1034.2	347.6	ab

Table 1: - continued

ID	P(days)	Nv	Vmax	Vmin	Av	$\langle V \rangle$	X	Y	type
3397	0.54092	75	19.48	20.43	0.95	20.068	1319.8	238.8	ab
3410	0.54146	75	19.66	20.41	0.75	20.139	1233.1	66.4	ab
3413	0.35955	75	19.93	20.36	0.43	20.115	1272.8	86.4	c
3468	0.29382	75	19.83	20.39	0.56	20.120	1118.1	428.8	c
3710	0.47382	84	19.67	20.10	0.42	19.875	1236.5	544.3	ab
3760	0.54851	84	19.75	20.50	0.76	20.320	1126.8	800.0	ab
3761	0.38447	84	19.80	20.44	0.63	20.214	1293.2	810.2	ab
3763	0.32214	84	19.90	20.50	0.60	20.176	1462.3	815.7	c
3777	0.63764	84	19.66	20.43	0.77	20.146	1237.7	881.2	ab
3801	0.36978	84	19.80	20.33	0.53	20.023	1285.6	969.5	c
3810	0.66197	84	19.61	20.43	0.83	20.130	1146.8	994.6	ab
3827	0.58776	84	19.62	20.50	0.88	20.185	1117.4	554.9	ab
3832	0.35651	83	19.96	20.34	0.38	20.158	1318.3	574.3	c
3834	0.37522	84	19.74	20.23	0.48	20.031	1431.4	580.3	c
3862	0.29408	84	19.95	20.53	0.58	20.242	1355.1	687.0	c
3888	0.60805	84	19.79	20.53	0.75	20.234	1350.5	791.0	ab
3907	0.58319	84	19.76	20.49	0.73	20.273	1124.2	856.2	ab
3916	0.30500	84	19.86	20.45	0.59	20.153	1026.9	887.9	c
3931	0.36016	83	19.94	20.46	0.52	20.248	1006.1	954.2	c
3934	0.51980	84	19.61	20.55	0.94	20.125	1141.8	975.3	abB
3938	0.37984	84	19.90	20.38	0.48	20.148	1326.5	989.1	c
3941	0.35695	84	19.91	20.37	0.46	20.148	1449.6	997.2	c
4233	0.35852	82	19.83	20.18	0.35	19.985	998.7	1063.6	c
4235	0.35566	83	19.92	20.42	0.50	20.199	1478.7	1080.4	c
4263	0.28478	73	19.91	20.55	0.65	20.267	1298.8	1219.2	c
4272	0.28239	84	19.95	20.41	0.46	20.151	1168.1	1238.9	c
4277	0.30630	84	19.91	20.42	0.50	20.212	1317.0	1268.8	c
4291	0.38799	84	19.88	20.28	0.41	20.074	1226.3	1324.7	c
4308	0.35896	84	19.92	20.38	0.46	20.135	1035.6	1391.2	c
4309	0.55430	82	19.68	20.44	0.76	20.169	1344.2	1394.4	ab
4313	0.73108	81	19.91	20.28	0.37	20.134	1421.8	1430.7	ab
4353	0.35981	84	20.01	20.41	0.40	20.178	1013.8	1104.1	c
4385	0.48740	84	19.46	20.61	1.15	20.322	1101.4	1243.5	ab
4686	0.61608	81	20.04	20.74	0.69	20.484	1427.1	1514.4	ab
4689	0.63920	81	19.57	20.36	0.80	20.006	1243.9	1527.7	ab
4747	0.59194	81	19.79	20.48	0.69	20.189	1409.1	1513.0	ab
4780	0.46386	81	19.49	20.33	0.84	19.912	1189.9	1660.9	d
4785	0.50611	80	19.48	20.60	1.13	20.266	1293.0	1701.9	ab
4786	0.53728	81	19.42	20.51	1.09	20.048	1393.8	1702.1	ab
4793	0.55984	81	19.50	20.43	0.93	20.133	1372.3	1756.2	ab
4812	0.48232	81	19.41	20.55	1.14	20.091	1343.7	1877.9	ab
4824	0.36224	81	19.73	20.30	0.56	20.054	1228.1	1988.7	c
5000	0.32325	71	19.88	20.43	0.56	20.095	1846.6	32.8	c
5011	0.27571	70	19.56	20.37	0.81	19.929	1543.5	147.6	cB
5015	0.37067	71	19.84	20.35	0.50	20.067	1665.6	188.1	c
5030	0.58271	71	19.91	20.49	0.58	20.226	1567.3	286.7	ab
5032	0.34702	71	19.90	20.40	0.51	20.144	1670.8	304.1	c
5049	0.64875	71	19.65	20.42	0.77	20.067	1848.8	391.6	ab
5065	0.38023	71	19.78	20.23	0.45	19.969	1699.6	460.2	c
5068	0.74402	71	19.88	20.25	0.36	20.055	1837.4	466.8	ab
5081	0.61752	71	20.02	20.19	0.18	20.120	1573.8	397.3	ab
5085	0.31931	51	19.82	20.44	0.62	20.057	1996.0	27.3	c
5105	0.55664	71	19.59	20.52	0.92	20.219	1784.8	157.9	ab
5123	0.32534	71	19.89	20.45	0.56	20.131	1558.6	268.1	c
5141	0.30468	71	19.86	20.44	0.58	20.247	1828.8	410.5	c
5155	0.56751	71	19.49	20.51	1.02	20.164	1645.6	476.0	ab
5330	0.39235	84	19.72	20.49	0.77	20.194	1701.6	586.8	ab
5343	0.54694	84	19.67	20.66	0.99	20.190	1964.0	621.7	ab
5344	0.64249	84	19.59	20.28	0.69	20.014	1988.6	627.0	ab
5354	0.67570	84	19.91	20.31	0.40	20.097	1530.3	712.4	abB
5359	0.67099	84	19.52	20.32	0.80	19.982	1528.6	732.6	ab
5364	0.28272	83	19.77	20.14	0.37	19.943	1898.5	744.6	c
5375	0.40155	84	19.77	20.28	0.51	19.990	1802.6	819.3	c
5376	0.38950	80	19.87	20.35	0.48	20.057	1623.3	820.7	c
5382	0.59593	84	19.76	20.58	0.81	20.164	1974.9	860.8	ab
5384	0.33483	84	19.96	20.43	0.47	20.091	1661.2	879.8	c
5390	0.65970	84	19.44	20.41	0.97	20.055	1575.5	910.7	ab

Table 1: - concluded

ID	P(days)	Nv	Vmax	Vmin	Av	$\langle V \rangle$	X	Y	type
5393	0.32275	84	19.82	20.34	0.52	20.039	1677.9	916.6	c
5397	0.61731	84	19.61	20.47	0.85	20.137	1964.9	918.2	ab
5400	0.32892	84	19.99	20.53	0.55	20.217	1574.0	943.0	c
5401	0.50380	84	19.72	20.45	0.74	20.182	1558.4	947.8	ab
5492	0.52879	84	19.59	20.53	0.94	20.247	1875.2	949.9	ab
5496	0.52504	84	19.86	20.56	0.70	20.314	1565.6	961.6	ab
5710	0.35581	80	19.91	20.40	0.49	20.139	1879.8	1035.8	c
5714	0.29291	81	19.95	20.51	0.56	20.207	1633.4	1054.8	c
5721	0.35831	81	19.93	20.39	0.47	20.220	1722.5	1103.4	c
5723	0.56602	81	19.88	20.52	0.64	20.246	1523.9	1107.0	ab
5724	0.49852	80	19.71	20.56	0.85	20.344	1767.7	1107.4	ab
5728	0.25120	81	19.91	20.43	0.51	20.154	1637.3	1139.9	c
5730	0.35188	81	20.05	20.41	0.36	20.178	1785.8	1148.5	c
5747	0.55986	81	19.55	20.42	0.87	20.131	1548.1	1323.3	ab
5751	0.39732	81	19.84	20.36	0.51	20.070	1664.8	1361.6	c
5773	0.50878	81	19.56	20.63	1.07	20.207	1652.6	1011.9	ab
5778	0.61096	81	19.74	20.45	0.71	20.197	1889.1	1022.3	ab
5802	0.51458	81	19.47	20.67	1.20	20.378	1592.4	1167.9	ab
5828	0.53714	81	19.54	20.58	1.04	20.277	1816.4	1377.0	ab
5845	0.36134	81	19.85	20.38	0.52	20.138	1853.1	1473.3	cB
6031	0.24634	82	19.90	20.39	0.49	20.093	1685.4	1634.8	c
6032	0.50902	83	19.64	20.46	0.82	20.169	1753.3	1635.5	ab
6034	0.60893	83	19.69	20.29	0.60	20.034	1817.9	1660.0	ab
6048	0.62679	83	19.89	20.43	0.54	20.157	1939.8	1847.3	ab
6050	0.30517	83	19.89	20.38	0.50	20.131	1546.0	1920.6	c
6085	0.36153	83	19.93	20.40	0.47	20.147	1597.4	1807.9	c

Table 2: Equatorial coordinates of variables from the central part of the Sculptor galaxy. Coordinates of 3 anomalous cepheids and 2 variable red giants are given at the end of table.

ID	RA(2000) deg	Dec(2000) deg	ID	RA(2000) deg	Dec(2000) deg	ID	RA(2000) deg	Dec(2000) deg
33	14.92432	-33.83240	1491	14.98180	-33.82260	2562	15.02418	-33.70730
37	14.93299	-33.82500	1519	15.00576	-33.80140	2566	14.97853	-33.70970
38	14.96458	-33.82000	1546	14.99830	-33.78680	2575	14.97613	-33.70690
54	14.93999	-33.79570	1553	15.04240	-33.77860	2606	14.99543	-33.69390
59	14.96322	-33.78990	1555	14.99009	-33.78160	2627	14.96712	-33.68650
71	14.91777	-33.78690	1558	14.97375	-33.78110	2639	14.99691	-33.67910
116	14.97255	-33.79850	1566	14.99146	-33.77700	2689	14.99448	-33.65190
321	14.91151	-33.76250	1823	14.97383	-33.73860	2699	14.98388	-33.65060
356	14.90564	-33.73870	1824	14.98155	-33.73710	2991	14.99496	-33.64630
357	14.92735	-33.73690	1830	15.01858	-33.73350	3004	14.98054	-33.63840
361	14.91075	-33.73360	1838	15.00214	-33.72870	3009	15.01450	-33.63310
366	14.93720	-33.72890	1873	14.98328	-33.71600	3016	15.00302	-33.63220
368	14.92808	-33.72940	1874	14.99275	-33.71540	3019	14.98840	-33.63180
377	14.96484	-33.72080	1875	15.02698	-33.71310	3024	14.96215	-33.62770
385	14.90586	-33.71970	1877	14.97852	-33.71540	3026	15.01235	-33.62330
403	14.90195	-33.76820	1890	15.00592	-33.76470	3039	15.02401	-33.60620
406	14.96991	-33.76240	1899	14.98055	-33.76910	3043	15.02532	-33.60430
411	14.93304	-33.76310	1910	15.02182	-33.76390	3044	14.97222	-33.60580
416	14.92731	-33.76240	1914	15.01456	-33.76340	3104	15.01257	-33.61650
439	14.93767	-33.74220	1926	14.96991	-33.76240	3113	14.98833	-33.61170
462	14.90621	-33.73410	1930	15.02574	-33.75580	3125	15.02585	-33.59860
463	14.92079	-33.73320	1932	14.97745	-33.75870	3126	15.01938	-33.59850
493	14.90354	-33.71900	1940	14.98223	-33.75510	3143	15.01764	-33.58590
737	14.90769	-33.71500	1941	15.00118	-33.75400	3318	15.09179	-33.82100
753	14.93654	-33.70360	1943	15.03828	-33.75030	3319	15.11376	-33.81950
763	14.92973	-33.69650	1997	15.02578	-33.72920	3320	15.09673	-33.81640
771	14.90183	-33.69460	2004	15.02232	-33.72730	3345	15.04600	-33.79500
782	14.90648	-33.68890	2012	15.02552	-33.72540	3346	15.08145	-33.79150
786	14.93024	-33.68370	2021	15.00775	-33.72410	3365	15.05007	-33.78540
793	14.92805	-33.67760	2048	15.00851	-33.71150	3397	15.09272	-33.79580
803	14.94209	-33.66870	2058	15.03372	-33.70740	3410	15.08215	-33.81740
811	14.95219	-33.66280	2059	14.99844	-33.70960	3413	15.08767	-33.81460
853	14.90020	-33.70210	2410	15.00678	-33.70740	3468	15.06128	-33.77480
860	14.90696	-33.69640	2421	14.99032	-33.70290	3710	15.07710	-33.75970
1132	14.93776	-33.64910	2422	15.03073	-33.70020	3760	15.05825	-33.73000
1139	14.95097	-33.63840	2423	15.03667	-33.69950	3761	15.08222	-33.72720
1142	14.93833	-33.63660	2424	14.97123	-33.70340	3763	15.10665	-33.72490
1149	14.92897	-33.63090	2425	14.98572	-33.70180	3777	15.07337	-33.71920
1164	14.90931	-33.61670	2450	14.98841	-33.69240	3801	15.07928	-33.70810
1168	14.92255	-33.60710	2455	14.96500	-33.69000	3810	15.05889	-33.70640
1178	14.89258	-33.59340	2458	15.01054	-33.68580	3827	15.05972	-33.75960
1204	14.90172	-33.64160	2467	15.03063	-33.68070	3832	15.08860	-33.75540
1256	14.89872	-33.59970	2470	14.99779	-33.68190	3834	15.10492	-33.75360
1261	14.94661	-33.59230	2471	15.00894	-33.68080	3862	15.09263	-33.74140
1411	14.99472	-33.82210	2482	14.96870	-33.68130	3888	15.09075	-33.72890
1424	15.04201	-33.80870	2502	14.96484	-33.67140	3907	15.05722	-33.72330
1439	15.04600	-33.79500	2528	15.01420	-33.66130	3916	15.04278	-33.72040
1446	15.03224	-33.79090	2545	15.00620	-33.65140	3931	15.03899	-33.71260
1457	15.00387	-33.78500	2552	14.98672	-33.69880	3934	15.05840	-33.70880
1462	15.02212	-33.77960	2555	14.98551	-33.67890	3938	15.08497	-33.70530
1470	15.02172	-33.77460	2558	15.03372	-33.70740	3941	15.10270	-33.70320
1482	15.03707	-33.77180	2559	14.99844	-33.70960	4233	15.03667	-33.69950

Table 2: - concluded

ID	RA(2000) deg	Dec(2000) deg	ID	RA(2000) deg	Dec(2000) deg	ID	RA(2000) deg	Dec(2000) deg
4235	15.10594	-33.69290	5068	15.16510	-33.76340	5721	15.14097	-33.68780
4263	15.07828	-33.67790	5081	15.12769	-33.77430	5723	15.11217	-33.68930
4272	15.05915	-33.67680	5085	15.19328	-33.81490	5724	15.14747	-33.68680
4277	15.08035	-33.67180	5105	15.16110	-33.80110	5728	15.12821	-33.68420
4291	15.06657	-33.66590	5123	15.12700	-33.79000	5730	15.14962	-33.68170
4308	15.03822	-33.65980	5141	15.16452	-33.77020	5747	15.11315	-33.66300
4309	15.08283	-33.65640	5155	15.13718	-33.76410	5751	15.12959	-33.65730
4313	15.09362	-33.65130	5330	15.14401	-33.75020	5773	15.13192	-33.69940
4353	15.03838	-33.69450	5343	15.18163	-33.74350	5778	15.16605	-33.69590
4385	15.04945	-33.67690	5344	15.18513	-33.74260	5802	15.12139	-33.68130
4686	15.09342	-33.64120	5354	15.11771	-33.73670	5828	15.15135	-33.65390
4689	15.06677	-33.64140	5359	15.11723	-33.73430	5845	15.15554	-33.64200
4747	15.09084	-33.64160	5364	15.17069	-33.72930	6031	15.12937	-33.62420
4780	15.05741	-33.62590	5375	15.15591	-33.72120	6032	15.13918	-33.62350
4785	15.07185	-33.62000	5376	15.12991	-33.72280	6034	15.14825	-33.61990
4786	15.08642	-33.61900	5382	15.18039	-33.71450	6048	15.16367	-33.59620
4793	15.08267	-33.61270	5384	15.13471	-33.71530	6050	15.10588	-33.59130
4812	15.07712	-33.59840	5390	15.12194	-33.71240	6085	15.11462	-33.60430
4824	15.05913	-33.58620	5393	15.13670	-33.71070	3302	15.06876	-33.79940
5000	15.17154	-33.81570	5397	15.17826	-33.70770	734	14.89081	-33.65870
5011	15.12622	-33.80470	5400	15.12135	-33.70850	5689	15.12568	-33.69510
5015	15.14345	-33.79860	5401	15.11903	-33.70810	274	14.89677	-33.73590
5030	15.12805	-33.78770	5492	15.16490	-33.70480	687	14.94274	-33.68980
5032	15.14285	-33.78460	5496	15.11992	-33.70630			
5049	15.16763	-33.77230	5710	15.16454	-33.69440			
5065	15.14519	-33.76550	5714	15.12864	-33.69450			

Table 3: Light curve parameters and rectangular coordinates of Sculptor anomalous cepheids and variable red giants. Coordinates X and Y are expressed in pixels (1 pixel equals 0.435").

ID	P(days)	Nv	Vmax	Vmin	Av	$\langle V \rangle$	X	Y
3302	1.34607	75	18.10	18.91	0.80	18.545	1153.2	222.4
734	1.15776	71	18.53	19.08	0.55	18.864	22.7	1480.7
5689	0.85541	81	18.65	19.35	0.70	19.135	1612.7	1051.3
274		69	17.23	17.12	0.11	17.17	13.8	838.5
687		83	17.09	17.20	0.11	17.15	359.7	1194.8

Table 4: Properties of RR Lyr variables in four dwarf spheroidal galaxies.  $N_{RR}$  is the total number of RR Lyr variables with known periods.  $n_{ab}$ ,  $n_c$  and  $n_d$  are relative frequencies of occurrence for RRab, RRc and RRd subtypes. Average periods for RRab and RRc variables are given in columns 6 and 7, respectively.

Object	$N_{RR}$	$n_{ab}$	$n_c$	$n_d$	$\langle P_{ab} \rangle$	$\langle P_c \rangle$	[Fe/H]
Carina	58	0.845	0.155	0.000	0.620	0.366	-2.2
Draco	131	0.878	0.046	0.076	0.614	0.351	-2.4
Sculptor	221	0.602	0.368	0.013	0.586	0.340	-1.9
Ursa Minor	82	0.573	0.427	0.000	0.638	0.375	-2.0